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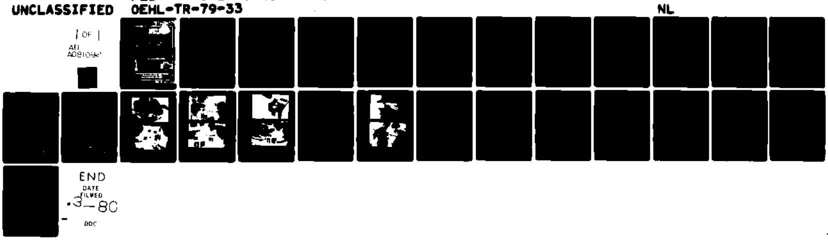

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Veterinarians and their assistants should consider the potential environmental hazards of chronic exposure to gaseous anesthetics. In humans, epidemiologic surveys have circumstantially shown adverse health effects following exposure to anesthetic gases. These effects include abortion, congential abnormalities, hepatic and renal diseases, CNS disturbances, increased risk of cancer and decreased fertility. In animals, similar effects due to occupational exposure levels of halothane and nitrous oxide have been experimentally established.

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Previous investigations regarding this personal and personnel health hazard have all concerned medical and dental personnel. There are no documented reports of the potential hazard to veterinary personnel. Therefore, the present survey was conducted to determine the exposure levels of halothane and nitrous oxide in selected USAF veterinary surgeries. In this survey, 11 of 35 halothane samples and 15 of 20 nitrous oxide samples exceeded the maximum exposure levels recommended by NIOSH for those compounds. A potential hazard to the health of personnel working in USAF veterinary surgeries exists A complete waste anesthetic gas management program and a periodic monitoring program should be maintained. (32 References).

TR-79-33

A SURVEY OF WASTE ANESTHETIC GAS LEVELS IN SELECTED USAF VETERINARY SURGERIES

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February 1979

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INTRODUCTION

We live in an age of increasing awareness and concern about occupational health and diseases associated with environmental pollution. Attention has recently been called to the possible adverse effects of trace anesthetic gases in the operating room (19). Veterinarians and their assistants who use gaseous anesthetics on a regular basis should consider the potential environmental hazards posed by these chemicals.

Interest in trace anesthetic gases was stimulated in 1967 by a survey of 303 Russian anesthesiologists who reported a high incidence of nausea, irritability, headache, fatigue and pruritus, and an alarming rate of spontaneous abortions (31). Subsequent to this report, a number of epidemiologic studies of humans, and laboratory experiments with animals have been conducted in an attempt to identify any prominent health effects associated with chronic exposure to waste anesthetic gases.

In humans, the major adverse health effects identified by the epidemiologic surveys were abortion and congenital abnormalities. An increased incidence of spontaneous abortion in exposed female workers (1,12-14,21-23) and of congenital abnormalities among their children (13,14,16,22,23) were found. The same increases among the unexposed wives and children of exposed men were also noticed (1,13,14,23). Furthermore, effects on fertility (22), hepatic and renal diseases (13,14,30), the CNS (15,30,31) and the risk of cancer (3,13,18) have been described following exposure to anesthetic gases.

Evidence that occupational exposure to gas anesthetics constitutes a health hazard, however, is only circumstantial. A cause and effect relationship in humans has not been documented. Other factors affecting medical personnel, such as stress, fatigue, and unfavorable working hours may be involved. Nevertheless, the potential harm of the long term exposure to anesthetic gases should not be ignored. Since the lag time between exposure and disease may be as long as 20 years, protection is necessary long before clinical manifestations of disease appear (33).

Recent experimental evidence for laboratory animal studies is supportive of the suggestion that health hazards are actually caused by anesthetic gas exposure. Fetal resorption has occurred in rats following exposure to nitrous oxide at levels within the range of occupational exposure (17). The teratogenic potential of halothane and nitrous oxide at occupational exposure levels has also been established in rats (4,8,9). Moderate liver and kidney damage has been observed in animals following chronic exposure to volatile halogenated anesthetics at levels associated with an occupational environment (6,7,10,27). Cerebral damage and permanent learning deficits have been seen in adult rats exposed to halothane at occupational levels (5,24). The same effect was seen in offspring of rats chronically exposed to occupational levels of halothane during pregnancy (4,26). Furthermore, it has been suggested that halothane and nitrous oxide, when administered simultaneously to rats at

occupational levels, might result in a synergistic cytologic or reproductive effect (20). Such a regimen has been shown to result in dose-dependent increases in cytogenetic aberrations in both bone marrow and spermatogonial cell populations, as well as a decrease in ovulation and implantation efficiency and retardation in fetal development (11).

Where do we stand in USAF veterinary anesthesia? Although all studies to date on this problem have been performed in human operating rooms, there is no reason to think that the problem is less important in veterinary facilities, where gas anesthetics are in frequent use. Obviously, veterinary anesthesiologists, surgeons, technicians and assistants breathe the same gases as their medical and dental counterparts. Some would argue that because of smaller patients, lower flow rates are used (25). However, levels of trace anesthetic gases in veterinary operating areas may well be greater than those reported for human facilities. The difficulties of high concentrations of halothane and high flow rates of oxygen and nitrous oxide for large animals, mask induction and maintenance of laboratory animals with potential leakage problems, along with frequent use of non-rebreathing systems all may contribute to high levels of these potentially hazardous gases (2).

Is breathing trace amounts of waste anesthetic gases in USAF veterinary surgeries a personal or personnel hazard? The evidence for or against is not available. There have been no scientifically documented reports of measurements of trace gases in veterinary hospitals. Only a limited study, sponsored by NIOSH (conducted by Whitcher and Hart at the Veterinary Medical Teaching Hospital, University of California at Davis, 1976) addresses the occupational exposure of veterinary personnel to inhalation anesthetics (19). In that study, the average breathing zone concentration of nitrous oxide, in the absence of control measures, was 310 ppm for two anesthetists during two different small animal surgical procedures. The average breathing zone concentration of halothane was 7.1 ppm for the anesthetists during surgery in a gelding. In both cases measurements were obtained using an infrared gas analyzer. Using appropriate scavenging techniques and control measures, the average breathing zone concentrations for anesthetists were reduced to 7.8 ppm for nitrous oxide and 0.35 ppm for halothane.

Until the present, we could only look at data gathered on human operating and dental treatment room personnel and conclude that efforts be made to depollute veterinary preparation, operating and recovery rooms. As a result, the following survey of waste anesthetic gases in selected USAF veterinary surgeries was conducted. The primary emphasis of this study was to establish analytically determined values of exposures levels to two commonly used inhalational anesthetics (halothane and nitrous oxide) at the breathing level of veterinary personnel in selected USAF veterinary surgeries.

METHODS AND MATERIALS

Sampling Dates and Protocol

Halothane and/or nitrous oxide levels were measured at five USAF veterinary surgical facilities, as follows:

	FACILITY	DATE
1.	USAFSAM/SGV Brooks AFB TX Operating Room #1	Dec 78
2.	USAFSAM/SGV Brooks AFB TX Operating Room #2	Feb 79
3.	Wilford Hall Medical Center Clinical Research Lab Lackland AFB TX	Dec 77
4.	Wilford Hall Medical Center Military Dog Veterinary Service Lackland AFB TX	May 77
5.	Aeromedical Research Lab Wright-Patterson AFB OH	May 78

The methods of anesthetic gas sampling included direct sampling using an infrared spectrophotometer, grab-bag sampling using an evacuated cylinder, and adsorbent trapping using an activated charcoal tube.

Infrared Spectrophotometry

Many compounds have characteristic absorption in the infrared region strong enough for both identification and quantitative determination by means of an infrared spectrophotometer (29). All of the anesthetic gases have one or more absorption bands in the infrared spectral region. By passing an infrared light beam of the proper wavelength through a cell containing the sample to be analyzed, the concentration of agent present can be determined by measuring the amount of infrared light absorbed. A specific measurement can be made by selecting a wavelength where other gases do not absorb. Halothane can be measured at wavelenghts of 8.45 μm, 8.8 μm and 12.3 μm. A wavelength of 12.3 μm is recommended when halothane is used in combination with nitrous oxide, to avoid interference from the latter. Nitrous oxide can be measured at wavelengths of 4.5 μm, 7.7 μm and 7.9 μm. The best sensitivity and least interference occurs in the 4.5 μm band for nitrous oxide. Excellent sensitivity is achieved by using a multi-pass, long pathlength cell, where the light beam is reflected back and forth through the sample many times (28).

Halothane and nitrous oxide levels were sampled directly at USAFSAM/SGV operating room number 2 (Figures 3-6) and at AMRL using the Wilks Miran-IA General Purpose Gas Analyzer. The Miran-IA portable gas analyzer (Figure 7) is a single-beam variable wavelength analyzer equipped with a 20 meter gas cell. The instrument is small enough (30 pounds) for use in the field. The variable pathlength feature allows the light beam to traverse through the sample many times, so a high enough absorbance value is obtained to achieve excellent sensitivity (28).

The parameters for sampling using the Miran-IA were:

PARAMETER	HALOTHANE	N_2O
Wavelength	12.3 μm	4.5 μm
Slit Setting	1.0 mm	1.0 mm
Absorbance Range	0-0.25 units	0-1.0 units
Pathlength	20.25 m	14.25 m
Volume	5.6 l	5.6 l
Windows	NaCl	NaCl

Calibration of the infrared spectrophotometer (Figure 8), construction of standard curves and calculations were accomplished using USAF OEHL methodology based on the Miran-IA Operation, Maintenance and Service Manual (Wilks/Foxboro Analytical, Norwalk CT, 1978). The Miran-IA calibration curves for halothane and nitrous oxide are shown in Figure 1 and Figure 2, respectively.

Bag Sampling

Sampling bags of Tedlar, Mylar, or Saran, or evacuated containers may be used for collecting air samples to be analyzed for anesthetic gas content. Samples collected in this manner may be analyzed for halogenated gases using gas chromatography and for nitrous oxide using the infrared spectrophotometric method (19).

A grab sample of air, to be analyzed for N_2O, was collected from the Military Dog Veterinary Service surgical facility. Sampling was accomplished by opening the valve on a 6 liter evacuated container and allowing it to reach atmospheric pressure. After sampling, all parts were sealed to minimize leakage in or out of the container. The container was transported to the laboratory for analysis of N_2O by the infrared spectrophotometric method.

Charcoal Tube Sampling

Charcoal tube sampling for halothane was accomplished at the following USAF veterinary surgical facilities using the indicated parameters:

FACILITY	FLOW RATE	SAMPLING TIME
USAFSAM/SGV - OR #1	0.2 l/min.	12 min.
Wilford Hall/Clinical Research Lab	0.5 l/min.	60 min.
Military Dog Veterinary Service	0.45 l/min.	44 min.

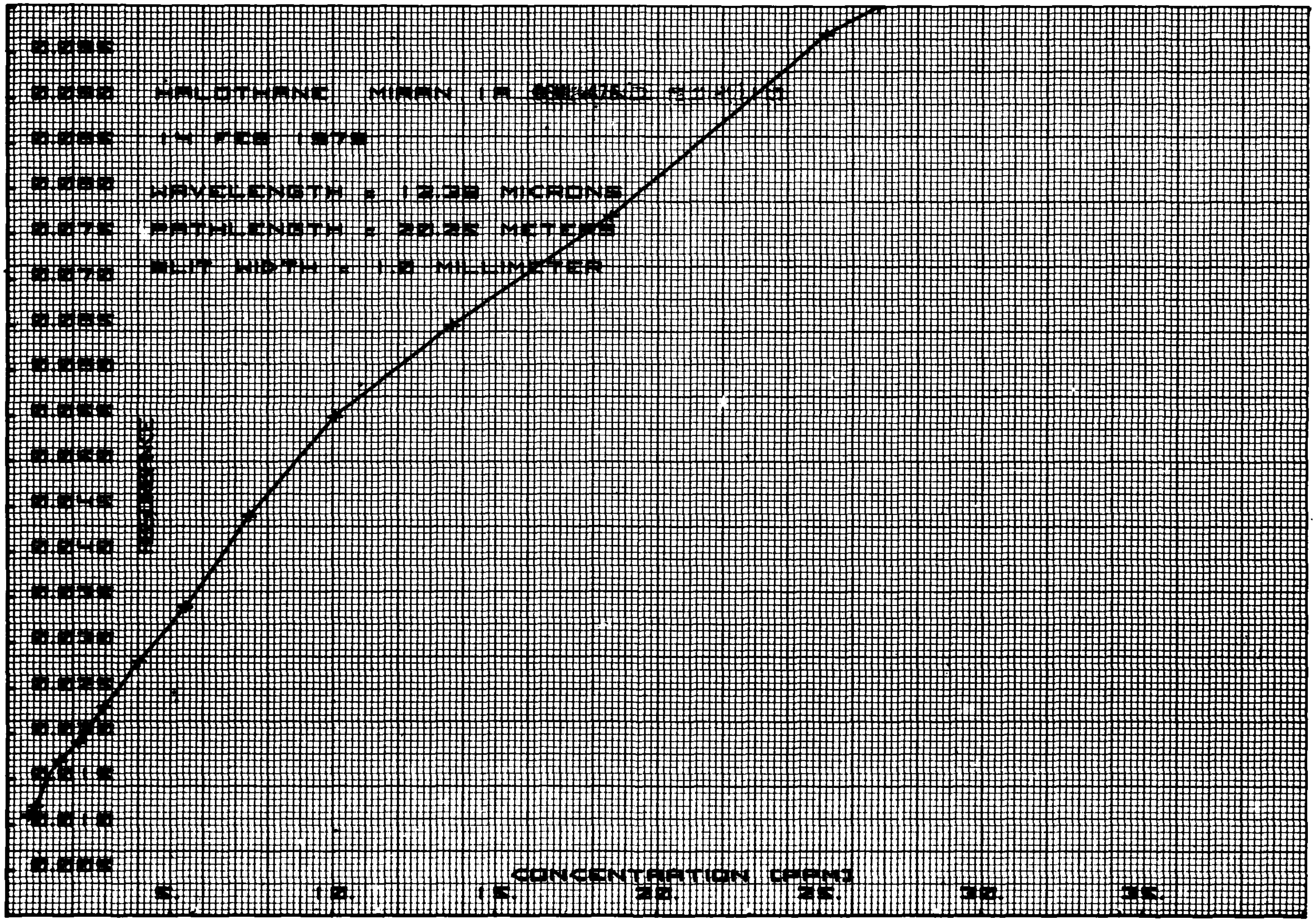

FIGURE 1. MIRAN-IA CALIBRATION CURVE OF STANDARD CONCENTRATIONS OF HALOTHANE.

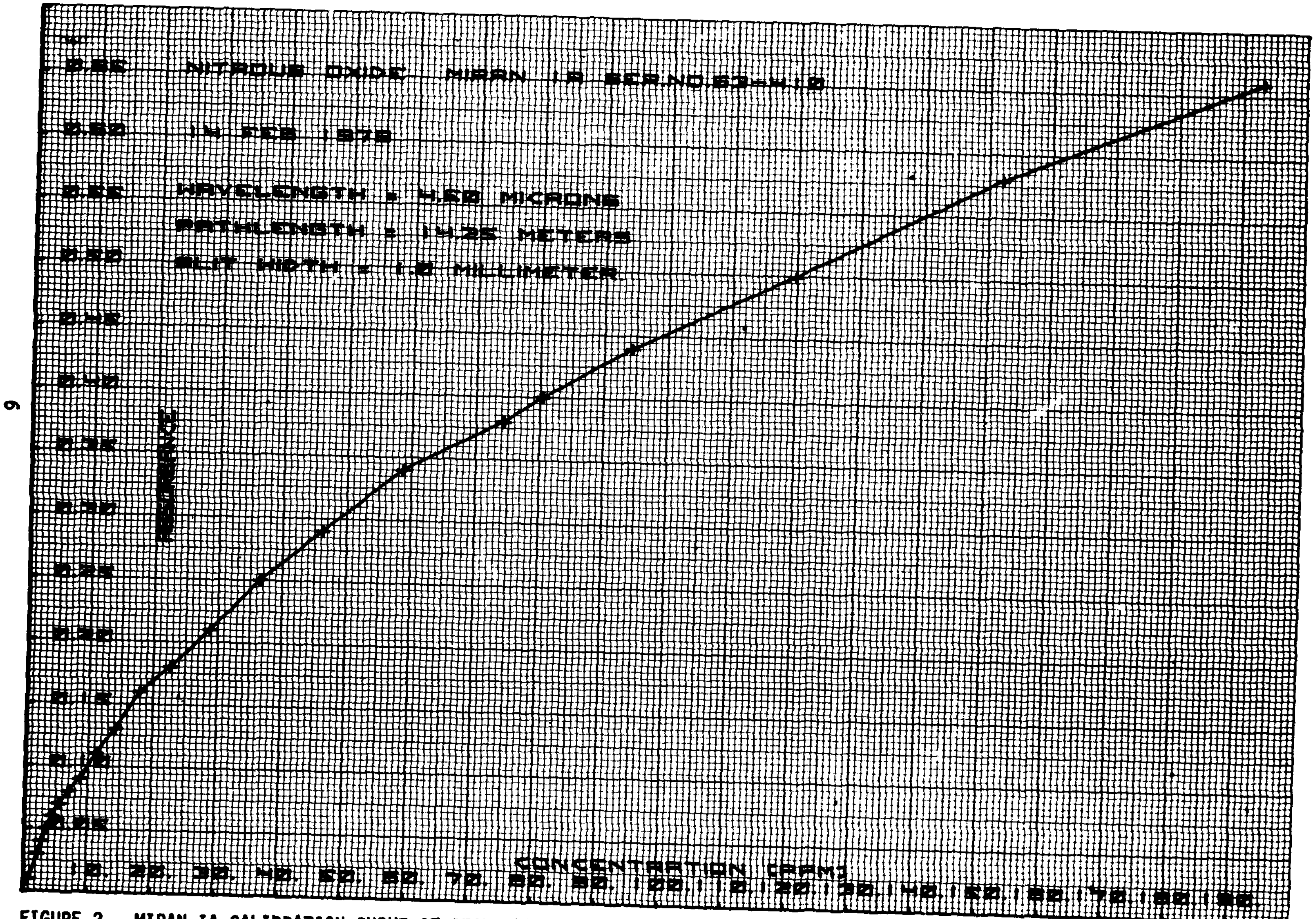

FIGURE 2. MIRAN-IA CALIBRATION CURVE OF STANDARD CONCENTRATIONS OF N_2O.

FIGURE 3. SIMULTANEOUS SAMPLING OF HALOTHANE AND N_2O AT THE BREATHING ZONE OF THE SURGEON.

FIGURE 4. SIMULTANEOUS SAMPLING OF HALOTHANE AND N_2O AT THE BREATHING ZONE OF THE ASSISTANT SURGEON.

FIGURE 5. SIMULTANEOUS SAMPLING OF HALOTHANE AND N_2O AT THE BREATHING ZONE OF THE ANESTHETIST.

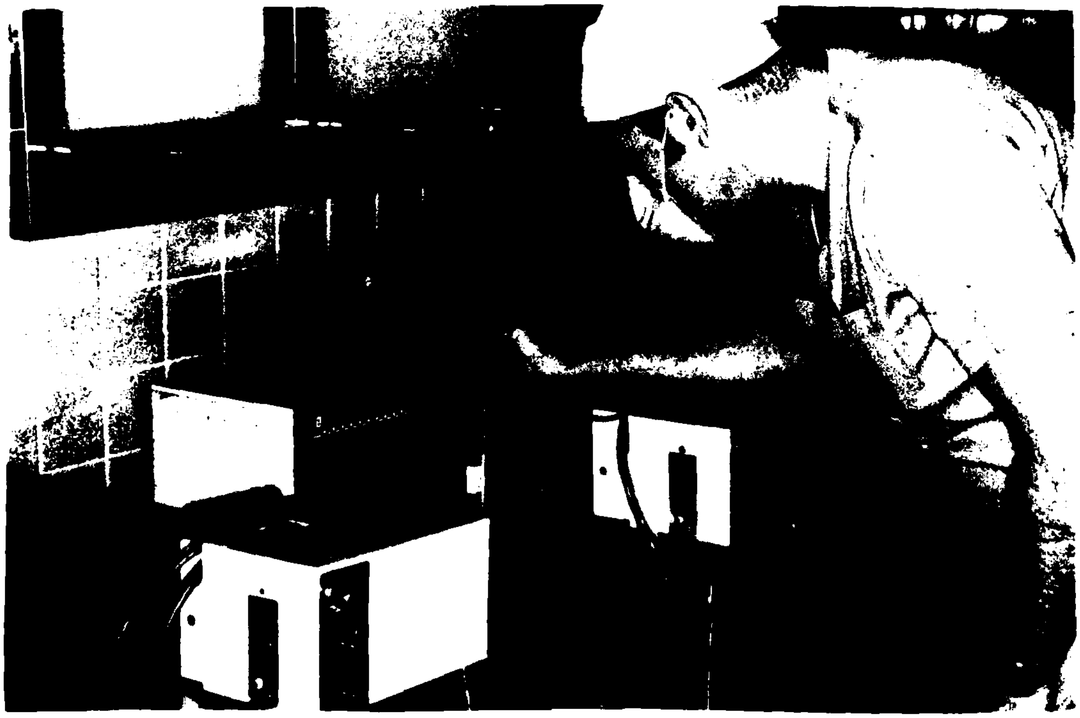

FIGURE 6. SIMULTANEOUS RECORDING OF HALOTHANE AND N_2O LEVELS DURING SAMPLING.

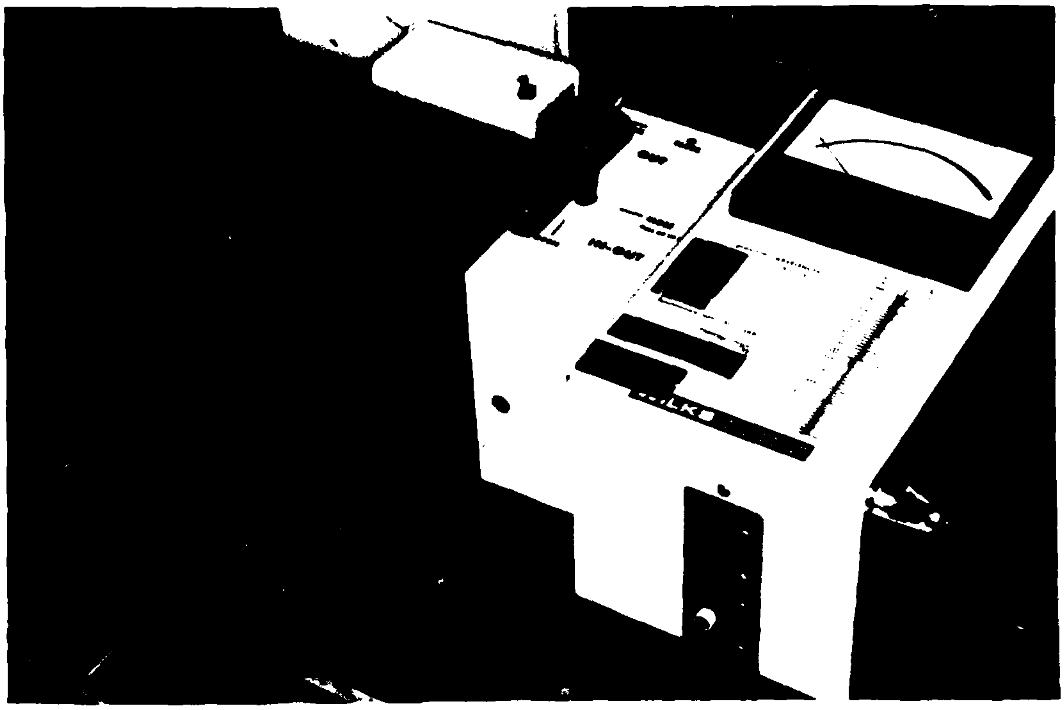

FIGURE 7. THE MIRAN-IA PORTABLE GAS ANALYZER.

FIGURE 8. CALIBRATION OF THE MIRAN-IA INFRARED SPECTROPHOTOMETER.

Samples were also collected at USAFSAM/SGV - OR #2 and at AMRL as backups for the infrared spectrophotometric analyses.

The charcoal tubes used were glass tubes with both ends flame-sealed, 7 cm long, 6 mm O. D. and 4 mm I. D., containing two sections of 20/40 mesh activated coconut shell charcoal separated by a 2 mm portion of urethane foam (Figure 9). Calibration, collection using a portable pump Figure 10), and gas chromatographic analysis were accomplished using the procedure outlined by NIOSH (19).

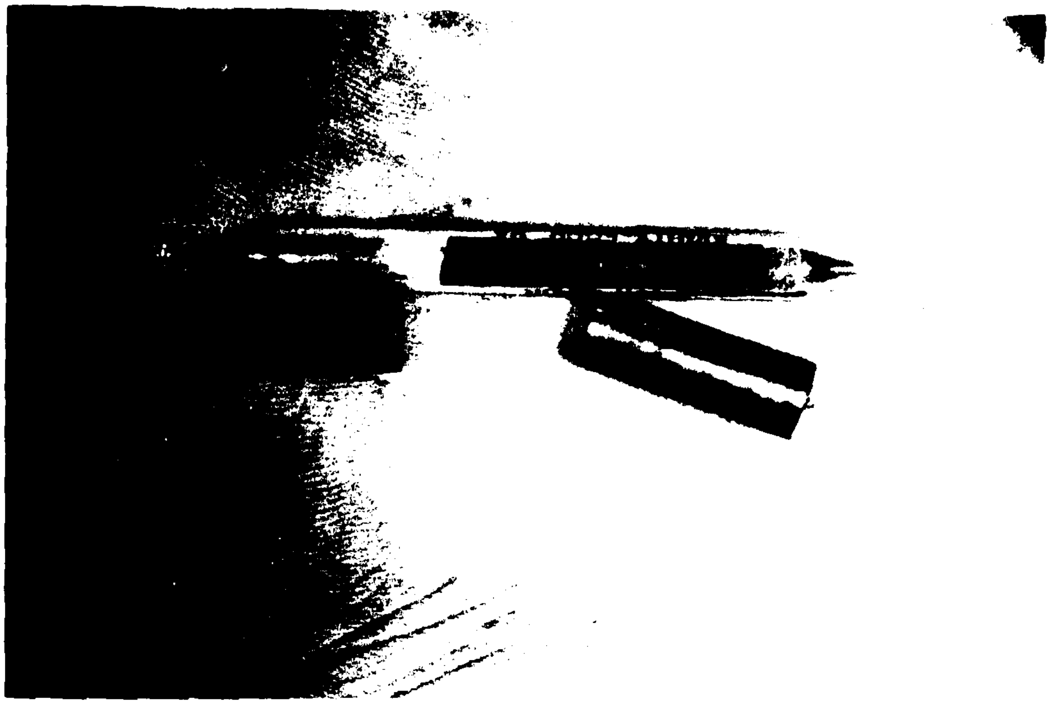

FIGURE 9. CHARCOAL TUBE.

FIGURE 10. ATTACHING CHARCOAL TUBES AND PUMPS TO THE ANESTHETISTS.

RESULTS AND DISCUSSION

The results of the survey of halothane and/or nitrous oxide levels in the operating room air of USAF veterinary surgical facilities are summarized in Tables 1-4. Animal species utilized during the surgical procedures were as follows:

FACILITY	SPECIES
1. USAFSAM/SGV - OR #1	Monkey
2. USAFSAM/SGV - OR #2	Dog
3. Wilford Hall/Clinical Research Lab	Dog
4. Military Dog Veterinary Service	Dog
5. AMRL	Rat

Except where indicated in the Tables, scavenging techniques and control measures recommended by USAF OEHL (32) were in use during the air sampling.

To insure personnel safety, NIOSH has recommended in its recent Criteria Document on Waste Anesthetic Gases and Vapors (19) that certain concentration levels should not be exceeded. These levels are:

(1) 2 ppm for halothane and methoxyflurane.

(2) 25 ppm for nitrous oxide when used alone or in combination with the halogenated agents. NIOSH recommends monitoring to insure that concentration levels are kept within safe limits.

In the present survey of selected USAF veterinary surgeries, halothane concentration levels ranged from 0.06 ppm to 37.2 ppm and nitrous oxide concentration levels ranged from 6 ppm to 270 ppm. In 11 of 35 samples collected, halothane concentration exceeded the maximum levels recommended by NIOSH. In 15 of 20 samples collected, nitrous oxide concentration exceeded the maximum levels recommended by NIOSH.

It is therefore obvious that a potential hazard to the health of personnel working in USAF veterinary surgical facilities exists. A complete waste anesthetic gas management program along with a periodic monitoring program as previously outlined by USAF OEHL (32) should be maintained in order to decrease personal chronic anesthetic exposure to the absolute minimum possible.

TABLE 1. LEVELS OF HALOTHANE (PPM) IN OPERATING ROOM AIR SAMPLED AT USAFSAM/SGV - OR #1, BROOKS AIR FORCE BASE. SAMPLES COLLECTED DECEMBER 1978.

COLLECTION SITE	HALOTHANE CONCENTRATION[a]	TIME[b]
Breathing Zone - Surgeon	0.6	1.5
	0.6	3.5
	1.5	4.5
Breathing Zone - Assistant Surgeon	0.2	1.5
	0.6	3.5
	0.7	4.5
Breathing Zone - Anesthetist	21.4[c]	1.5
	37.2[c]	3.5
	8.4[c]	4.5
Breathing Zone - Technician	0.7	1.5
	1.5	3.5
	1.1	4.5

[a]Time weighted average (ppm)
[b]Hours after start of surgery
[c]A leak was detected around the mask of the patient

TABLE 2. LEVELS OF HALOTHANE (PPM) AND NITROUS OXIDE (PPM) IN OPERATING ROOM AIR SAMPLED AT USAFSAM/SGV - OR #2, BROOKS AIR FORCE BASE. SAMPLES COLLECTED FEBRUARY 1979.

COLLECTION SITE	ANESTHETIC GAS CONCENTRATION[a] HALOTHANE	NITROUS OXIDE	TIME[b]
Breathing Zone - Surgeon	0.6	86	0.5
	0.6	120	1.0
	0.6	120	1.5
Breathing Zone - Assistant Surgeon	0.6	49	0.5
	0.4	62	1.0
	0.6	86	1.5
Breathing Zone - Anesthetist	18.0	27	0.5
	0.2	27	1.0
	2.4	270	1.5
Breathing Zone - Technician	0.4	14	0.5
	0.2	11	1.0
	0.2	11	1.5
Animals Head	3.4	223	0.5
	2.4	210	1.0
	1.2	167	1.5

[a]Time weighted average (ppm)
[b]Hours after start of surgery

TABLE 3. LEVELS OF HALOTHANE (PPM) AND/OR NITROUS OXIDE (PPM) IN OPERATING ROOM AIR SAMPLED AT THE CLINICAL RESEARCH LAB AND THE MILITARY DOG VETERINARY SERVICE OF WILFORD HALL, LACKLAND AIR FORCE BASE. SAMPLES COLLECTED DECEMBER 1977 AND MAY 1977, RESPECTIVELY.

COLLECTION SITE	ANESTHETIC GAS CONCENTRATION HALOTHANE[a]	NITROUS OXIDE[b]
Clinical Research Lab Breathing Zone - Anesthetist	0.06	-
Military Dog Veterinary Service Breathing Zone - Anesthetist	5.4	6 28

[a]Time weighted average (ppm)
[b]Grab samples (ppm)

TABLE 4. LEVELS OF HALOTHANE (PPM) AND NITROUS OXIDE (PPM) IN OPERATING ROOM AIR SAMPLED AT AMRL. SAMPLES COLLECTED MAY 1978.

COLLECTION SITE	ANESTHETIC GAS CONCENTRATION[a] HALOTHANE	NITROUS OXIDE
Floor Level	1.7	14
Animals Head	2.7	-
Breathing Zone - Surgeon	1.5	-
Breathing Zone - Anesthetist	2.0	-
(Expelling Bag)	5.0	-
Breathing Zone - Anesthetist (Manual Ventilation)	4.0	100 120[b]

[a]Time weighted average (ppm)
All samples collected with scavenger on, except where noted
[b]Sample collected with scavenger off

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